Pioneer 10 and 11 Mission Support

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This article describes the major elements involved in the total Ground Data System which supports the Pioneer 10 and 11 missions as it exists during the Pioneer 10 Jupiter encounter time frame.

I. Introduction

An additional unique aspect of the Pioneer 10 Jupiter encounter is that it will be the first major unmanned mission event the Jet Propulsion Laboratory has supported involving a remote control center. This means that this is the first unmanned mission supported by JPL where the mission operations control did not reside within JPL facilities located in Pasadena, California. This article describes the major elements involved in the total Ground Data System which supports the Pioneer 10 and 11 missions as it exists during the Pioneer 10 Jupiter encounter time frame.

Figure 1 depicts the major elements that comprise the total Ground Data System. The next three section headings correspond to the three major sections in the Ground Data System which are geographically separated. Paragraph headings within the three sections correspond to the elements portrayed in Fig. 1 within the three geographic locations. The following discussion concentrates on the data flow through the Ground Data System. The operations control, or "people" interface, will be shown on a separate chart and described in a subsequent article. Note that Fig. 1 is not necessarily a logical breakdown to a uniform level of detail in all elements of the Ground Data System, but rather a convenient construction for this discussion.

II. Deep Space Station

The station configuration is essentially identical for the encounter phase as for Pioneer 10 and 11 cruise support, except that a higher level of redundancy is provided for

critical mission periods. There are four major elements within the Deep Space Station (DSS) and within the DSN: the Telemetry, Command, Tracking, and Monitor Systems.

The Monitor System collects status and performance information in real time for transmission by high-speed data line (HSDL) and further processing for use by DSN Operations Control. The monitor data are not used by the Project. The ground communications form an additional DSN system and is comprised of voice, high-speed data, and teletype transmission equipment.

Telemetry. The DSS Telemetry Subsystem detects the telemetry subcarrier, acquires bit (or symbol in coded mode) synchronization, decodes coded data, and produces a Digital Original Data Record for recovery of data lost during real-time transmission. The Telemetry Subsystem formats the telemetry data for high-speed data transmission and provides an off-line capability for performing data recalls.

Command. The Command Subsystem receives command instructions via high-speed data, stores a number of commands for later transmission either when enabled or at pre-selected times, sends the commands to the modulator in the exciter, and performs various self-checking functions to assure that commands are transmitted without error.

Tracking. The Tracking Subsystem receives predictions via high-speed data for controlling the transmitter and ground reference frequency, and for pointing the antenna. The Tracking Subsystem also generates and samples doppler and angle information, and formats this information, called radio metric data (RMD), for high-speed data transmission.

III. Mission Control and Computing Center

The Mission Control and Computing Center (MCCC) currently provides real-time engineering processing for the Project, navigation processing, and the processing for DSN Operations Control functions. Telemetry data can be processed directly by the Ames Research Center (ARC), which is currently used as a backup mode of operations.

360/75 Real-Time System. The real-time system provides real-time engineering data processing including production of Project telemetry formats for local display and transmission to ARC, radio metric data processing including pseudo-residuals, and a Master Data Record (MDR) for processing by the Navigation Team. DSN

Operations Control processing, including the generation of predicts and Monitor System data displays, resides in the 360/75. The telemetry and command Master Data Records are produced in this system and shipped to ARC. Extensive command processing, including command file creation and manipulation is also provided.

DSN Operations Control. The DSN Operations Control area resides in the MCCC and is the location where all DSS real-time activities are monitored and controlled.

MCCC Operations Control. MCCC self-monitoring and control functions are carried out in the MCCC.

Pioneer Mission Support Area. A limited Pioneer Project staff mans the Pioneer Mission Support Area (PMSA), which is an area provided in the MCCC. Most of the 360/75 displays are available only to the few Project operators located in this area. This area supplements the Pioneer Project real-time operations and serves as a backup mission operations center in the event of a failure in ARC equipment or the communications between JPL and ARC.

Navigation. The Navigation Team is a JPL-supported function for the Pioneer Project which utilizes the 1108 computer system for orbit determination and maneuver analysis by processing the radio metric data.

360/75 Off-Line. An off-line 360/75 (not shown in Fig. 1) will be utilized for limited time periods to support special tracking predict generation necessary for the special use of digitally controlled oscillators during the Pioneer 10 encounter.

IV. Pioneer Mission Control Center

The Pioneer Mission Control Center (PMCC) is located at the Ames Research Center and the principle real-time processing is performed on a Sigma 5. There are three Sigma 5's at ARC with one ordinarily processing Pioneer 10 data, one processing Pioneer 11 data, and the third serving as a backup and performing off-line processing. During critical encounter periods, Pioneer 11 data will be processed in the direct mode to relieve 360/75 loading.

Sigma 5 Real-Time System. This system does some limited engineering telemetry processing plus all of the science telemetry processing, and it produces listings for use by the experimenters. In addition, it accepts command instructions and interfaces with the 360/75 command software via high-speed data in standard NASA Communications (NASCOM) blocks.

Sigma 5 Off-Line System. The off-line system serves as a backup to the on-line and processes the received MDRs to produce the Experimenters' Data Record (EDR).

V. Summary

The Ground Data System is complex for the support of Pioneers 10 and 11. This complexity is particularly evident in command operations. During Pioneer 10 and 11 operations, including encounter, all commands will be entered by operators at ARC into the Sigma 5 for high-speed transmission to the 360/75 at JPL, extensive processing in the 360/75, then high-speed transmission to the Telemetry and Command Processor in the Deep Space Station, and finally through the transmitter link and radiated to the spacecraft. There is then a large number of individual elements in the command path which must all be working properly to assure command flow. Fortunately, backup plans exist to continue command operations in the event of failures in specific areas of the total Ground Data System. For example, commanding could be performed from the PMSA in the event of a failure in the PMCC, and a small number of commands can be entered directly by station personnel at the DSS when necessary.

Recognizing the complexity of the Ground Data System for Pioneers 10 and 11, ARC intends to implement a direct interface between the PMCC and the DSS after Pioneer 11 encounter some time in early 1975.
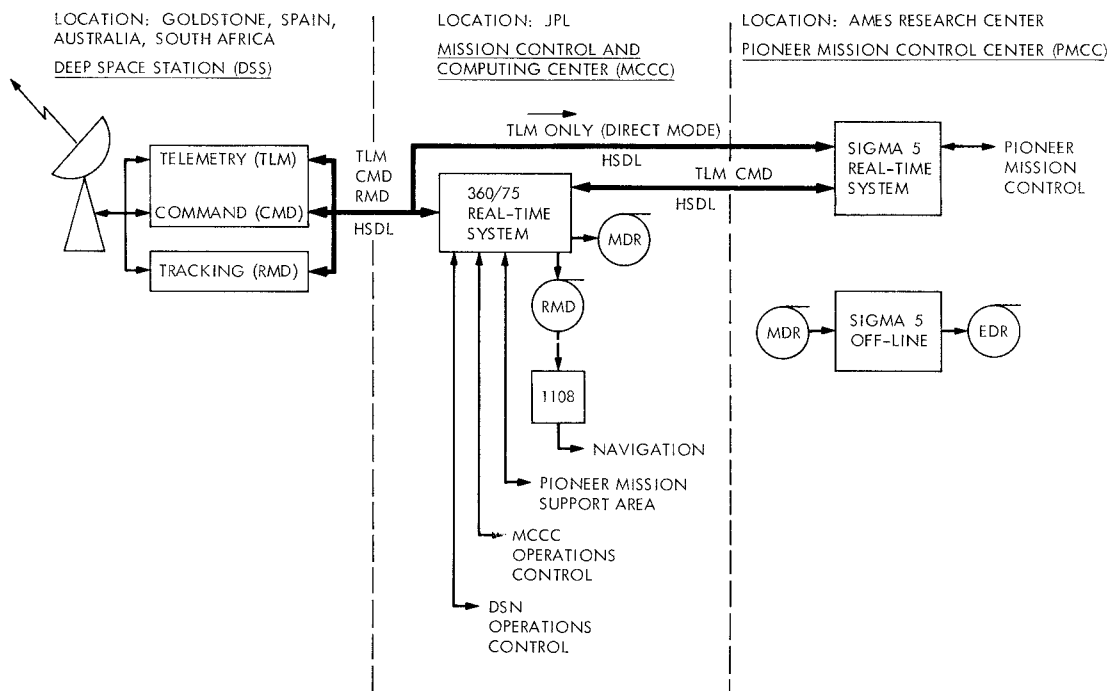
Fig. 1. Pioneer 10 Ground Data System during Jupiter encounter